FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

		ATTORNEY'S DOCKET NUMBER 10806-176
		U.S. APPLIC. NO. (if known, see 37 CFR 1.5) 09/936653
INTERNATIONAL APPLICATION NO. PCT/EP00/02537	INTERNATIONAL FILING DATE 16 March 2000	PRIORITY DATE CLAIMED 16 March 1999
TITLE OF INVENTION	HYDROPHILIC MACROMOLECULAR COMPOUNDS	
APPLICANT(S) FOR DO/EO/US	**HODD**, Kenneth A.; **DILLINGHAM**, Keith Alfred; **de GROOT**, Jaqueline; **HAITJEMA**, Henrik	

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)

6. [] A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendment has NOT expired.
   d. [X] have not been made and will not be made.

8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. [] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. [] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment.
    [] A SECOND or SUBSEQUENT preliminary amendment.

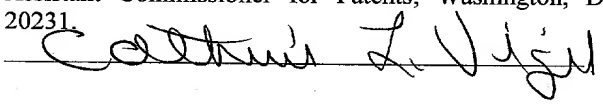
14. [] A substitute specification.

15. [] A change of power of attorney and/or address letter.

16. [X] Other items or information: Copy of published International Application No. WO 00/55214, including International Search Report

CERTIFICATE OF MAILING

"Express Mail" mailing label #: EL378869662US
Date of Deposit: September 14, 2001
I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to: Box PCT; Assistant Commissioner for Patents; Washington, DC 20231.



U.S. APPLIC. NO. (if known, see 37 CFR 1.50) 09/936653	INTERNATIONAL APPLICATION NO. PCT/EP00/02537	ATTORNEY'S DOCKET NUMBER 10806-176

	CALCULATIONS	PTO USE ONLY
17. The following fees are submitted:		
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
[X] Search Report has been prepared by the EPO or JPO $860.00		
[] International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00		
[] No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00		
[] Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1000.00		
[] International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

Claims	Number Filed		Number Extra	Rate		
Total Claims	24	-20 =	4	x $18.00	$ 72.00	
Independent Claims	2	-3 =	0	x $80.00	$	
Multiple dependent claim(s) (if applicable)				+ $270.00	$	

TOTAL OF ABOVE CALCULATIONS =	$1062.00	
[] Applicant(s) claim(s) small entity status, 37 C.F.R. 1.27. The fees indicated above are reduced by 1/2.	$	
SUBTOTAL =	$1062.00	
Processing fee of $130.00 for furnishing the English translation later than the [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$	
TOTAL NATIONAL FEE =	$1062.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$	
TOTAL FEES ENCLOSED =	$1062.00	
Amount to be refunded		$
Amount to be charged		$

a. [X] A check in the amount of $1,062.00 to cover the above fees is enclosed.

b. [] Please charge my Deposit Account No. in the amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-1133.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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Holly D. Kozlowski
TYPED OR PRINTED NAME

14 September 2001
DATE

BASED ON FORM PTO-1390 (Rev. 10-2000)

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10806-176

Docket No. 10806-176

CERTIFICATE OF EXPRESS MAILING

PATENT

Express label #: EL378869662US
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Catherine L. Voight

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Applicant:	Kenneth A. Hodd et al	:	Paper No.:
Serial No.:	To be assigned	:	Group Art Unit:
Filing Date:	September 14, 2001	:	Examiner:

For: **Hydrophilic Macromolecular Compounds**

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, DC 20231

Dear Sir:

Prior to calculation of the filing fee and first action by the Examiner, please amend the present application as follows:

In the Claims:

Please amend claims 13, 16, 20, 23 and 24 to read as follows:

13. (Amended) Photocrosslinkers according to claim 1 provided with functional groups for crosslinking.

16. (Amended) A method of forming a macromolecular crosslinked network from an aqueous composition comprising a photocrosslinker according to claim 1 by irradiating with light exceeding a wavelength of about 305 nm for a time sufficient to form a solid article.

20. (Amended) A method according to claim 16, wherein an ophthalmic lens is produced from said composition.

23. (Amended) An ophthalmically acceptable composition comprising the photocrosslinkers according to claim 1, having a refractive index of at least 1.39 and a suitable viscosity to be injected through a standard cannula of 15 Gauge, or finer.

24. (Amended) A method of forming an intraocular lens, comprising injecting an ophthalmically acceptable composition comprising photocrosslinker according to claim 1 into the capsular bag of the eye.

REMARKS

By the present Amendment, claims 13, 16, 20, 23 and 24 are amended to omit their multiple dependency. Additionally, claim 24 is amended to omit the recitation of a use and to recite a method of forming an intraocular lens, in accordance with the teachings throughout the specification. A Version With Markings Showing Changes Made is attached. Since these changes do not involve any introduction of new matter, entry is believed to be in order and is respectfully requested.

Respectfully submitted,

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715941.01

VERSION WITH MARKINGS SHOWING CHANGES MADE

Claims 13, 16, 20, 23 and 24 are amended as follows:

13. (Amended) Photocrosslinkers according to claim 1 [or 7] provided with functional groups for crosslinking.

16. (Amended) A method of forming a macromolecular crosslinked network from an aqueous composition comprising a photocrosslinker according to [any of claims 1 to 14] claim 1 by irradiating with light exceeding a wavelength of about 305 nm for a time sufficient to form a solid article.

20. (Amended) A method according to [any of claims 16 to 19] claim 16, wherein an ophthalmic lens is produced from said composition.

23. (Amended) An ophthalmically acceptable composition comprising the photocrosslinkers according to [any of claims 1 to 15] claim 1, having a refractive index of at least 1.39 and a suitable viscosity to be injected through a standard cannula of 15 Gauge, or finer.

24. (Amended) [The use of photocrosslinkers according to any of claims 1 to 15 in] A method of forming an intraocular lens, comprising injecting an ophthalmically acceptable composition comprising photocrosslinker according to claim 1 [for injection] into the capsular bag of the eye.

Hydrophilic Macromolecular compounds

Field of invention

The present invention relates to photocrosslinkers providing a combination of photoinitiating and crosslinking processes capable acting in an aqueous environment and being activated by visible light.

Background of invention

The UV curing of resin formulations is widely used in industry as the setting process for coatings, adhesives, and more recently paints. Such formulations may comprise a combination of vinyl, usually acrylate, monomers and crosslinkers, together with a photoinitiator. Other possible constituents of the formulations include crosslinkers and vehicles. In general an advantage of photocurable formulations is that the monomers act as their own vehicle, and the use of solvent is obviated, which has environmental advantages.

Advances in the technology of photocuring, improvements such as, those in UV lamps, cationic initiators for epoxide-based formulations, water borne coatings, and many novel monomers has enabled this production process to penetrate a number of important manufacturing sectors. Photopolymerization is now used in photoresists for printed circuits and microelectronics, for photolithography, magnetic recording media, glass-fiber laminates, and for medical devices, especially for dental and ophthalmic applications.

European Patent 0800 657 describes a photoinitiator linked to a macromer structure which together with a copolymerizable monomer and a crosslinker is capable forming a polymerization product, such as an ophthalmic lens that retains photoinitiator radical in the resulting network. This is advantageous in medical applications wherein such potentially harmful radicals must be carefully controlled. However, this system would not be applicable for producing a polymerized product directly in the capsular bag in the eye since it is not directed to photoinitiators activated by light in the visible range.

For the medical applications of photopolymerization it is usual to employ visible light, rather than UV, to effect the cure of the resin formulation. The use of visible, usually blue, light avoids exposing patient and dentist or surgeon to harmful irradiation. Increasingly, the merit of this approach is being recognized for industrial practice, where operatives also need protection from prolonged exposure to harmful UV.

It is a characteristic of almost all, if not all, of the formulations used for aforementioned types of application that they are crosslinked. Crosslinking of the polymeric bases, which constitute the coatings, or artifacts of the aforementioned industrial products confers important advantages upon them. Crosslinked polymers have greater environmental (e.g. temperature and moisture) resistance, solvent resistance and dimensional and mechanical stability, than equivalent linear polymers. This is especially so for where the equivalent linear polymer are produced by photopolymerization they have an atactic, non-crystalline, structure.

Crosslinking is introduced into photopolymerized products by including in the formulation for the resin, coating or gelling system, an acrylate, or similar, crosslinker, which is characterized by having two or more crosslinkable acrylate or vinyl functions. In some formulations this crosslinking species is a polymer of low molecular weight. The crosslinker copolymerizes with the monomers of the formulation to produce a network structure.

It is an object of the present invention provide macromolecular compounds which act as hydrophilic photocrosslinkers for a great number of different polymeric systems provided with functional groups for crosslinking or with vinylic, acrylic and methacrylic monomers in aqueous solution and thereby retaining the photoactive radical in the crosslinked network.

It is another object of the present invnetion to provide stable hydrophilic photocrosslinkers capable of being activated at wavelengths greater than 305 nm.

It is a further object of the present invention to provide photocrosslinkers with capability to act in aqueous solutions, especially on hydrophilic polymers or water-soluble macromolecular particles made thereof having functional groups for crosslinking.

It is a still further object of the present invention to provide photocrosslinkers with

enhanced photoactivity (100 % conversion of monomer to polymer in aqueous solution) which reduces photoinitiator residues to a minimum, especially, vinyl modifications of the photoinitiator component and thereby reducing compositional drift, Draize and other environmental hazards.

The invention as presented below will explain how the mentioned objects are met while discussing further obvious advantages.

Description of the invention

The present invention pertains to macromolecular hydrophilic photocrosslinkers having a general formula $(A)_n(B)_m(C)_p$, wherein

(i) A, B and C are units of substituted ethylene groups in the macromolecular structure;

(ii) A, B and C are randomly distributed and the unit C carries a photoactive group;

(iii) n = 0-98 mole %, m = 0-98 mole %, n+m = 50-98 mole % and p = 0.5-50 mole %.

When the photoactive groups of units C are exposed to light of determined wavelengths above 305 nm, radicals are generated which are retained on the macromolecular photocrosslinkers and will react to form a crosslinked network structure. Preferably the final structure is solid article.

The photocrosslinker further preferably further comprises functional groups for crosslinking. Such groups are conventionally vinylic, acrylic or methacrylic groups and their nature and introduction on polymeric backbone are well known to persons skilled in the art and will be referred to as "functional groups for crosslinking".

According to one aspect of the invnetion an aqueous composition of the photocrosslinker in a suitable amount can be directly crosslinked into the final solid product upon sufficient irradiation. In another aspect the aqueous composition for crosslinking into a solid article comprises suitable amounts of the photocrosslinker and a hydrophilic polymer carrying functional groups for crosslinking. The photocrosslinker in such a system will thereby replace the conventional combination of crosslinker and

photoinitiator. Applicable hydrophilic polymers with suitable functional can readily be provided with the skilled person for the purpose of crosslinking desired articles. For example it would be conceivable to employ polymers having a sufficiently high refractive index to be acceptable as intraocular lenses. As a further suitable example aqueous compositions of water-soluble pre-formed functionalized particles of hydrophilic polymers according to the International Patent Application PCT/EP99/04715. In a still another aspect of the present invention, the photocrosslinkers can be employed in a composition, preferably an aqueous composition further comprising at least one copolymerizable vinylic, acrylic or methacrylic monomer. Such monomers and combinations thereof are well known in the art and will not be described herein in further detail. It is, however, to be understood that the photocrosslinker will replace conventional crosslinking agents and their combination with photoinitiators in such systems.

It is highly preferred that the photoactive groups of the photocrosslinkers comprise a phosphine oxide, in order to generate the necessary radicals for crosslinking from the exposure of visible light. More preferably, the photoactive group is an acyl- or aroyl phosphine oxide.

According to a preferred aspect, the photoactive group is linked to the ethylene groups of units C of the photocrosslinkers by a linking group comprising a phenylene group. Optionally, such a phenylene group is substituted in order to obtain more stability. The photoactive group can also be linked to said the ethylene groups by means of a linking group comprising a group having the structure –O-C(O)-NH-, i.e. a urethane bridge. Preferably, such a linking group has a structure of -O-C(O)-NH-Ph-, wherein Ph denotes an optionally substituted phenylene group.

According to one embodiment of the invention, the photocrosslinkers comprises substituted ethylene units A, B, C of a macromolecular photocrosslinker in according to:

A= $-CH_2-C(R^1R^2)-$, B= $-CH_2-C(R^1R^3)-$, C= $-CH_2-C(R^1R^4)-$, wherein

R^1 is hydrogen or methyl;

R^2 is -CON(Me)$_2$, -$CO_2CH_2CH_2OH$, -$OCOCH_3$, -$OCOCH_2CH_2Ph$, -OH or a lactam group;

R^3 is -CON(Me)$_2$, -$CO_2CH_2CH_2OH$, -$OCOCH_3$, -$OCOCH_2CH_2Ph$, -OH or a lactam group when B is -CH_2-$C(R^1R^3)$- with the proviso that R^2 and R^3 are not the same unless R^2 and R^3 is -OH ; and

R^4 is -$R^5C(O)P(O)$ R^6R^7 or –$R^5P(O)R^6OC(O)R^7$, wherein R^5, R^6 and R^7 are selected among same or different aryl groups comprising phenyl, methylphenyl, dimethylphenyl, trimethylphenyl, methoxyphenyl, dimethoxyphenyl, trimethoxyphenyl, methylolphenyl, dimethylolphenyl, trimethylolphenyl or styryl radicals, or

R^4 is – $R^8C(O)P(O)$ R^9R^{10}, wherein R^9 and R^{10} are the same as R^5, R^6 and R^7 above, but R^8 is a group –O-C(O)-NH- R^{11}, wherein R^{11} is the same as R^9 and R^{10}.

In the general formula above, -OH denotes a hydroxyl group, Me a methyl group and Ph is a phenyl group. The lactam group typically is a heterocyclic ring structure of 4 to 7 atoms of which at least one is nitrogen. A suitable such lactam group provides a N-vinyl-pyrrolidone structure as one of units A or B on said ethylenic backbone. It is also to be understood that besides the mentioned substituents functional groups for crosslinking can be added to the macromolecule in accordance with conventional methods.

In one advantageous embodiment, the photocrosslinkers, R^2 and R^3 according to above are selected so as to form a water-soluble molecule.

Suitable units A and B in the general formula $(A)_n(B)_m(C)_p$ are selected among, but not limited to, N-vinylpyrrolidone (NVP), 2-hydroxyethylmethacrylate, N-N-dimethyl-acrylamide and vinyl acetate. The vinyl acetate referred to preferably will be hydrolyzed conventionally to vinyl alcohol. It is also referred to Table 1 below in the exemplifying part of the description for a number of specific photocrosslinkers based on such units (or co-monomers) and 4-vinylbenzoyl-diphenylphosphine oxide (VBPO) as a photoinitiating group. Accordingly, VBPO units constitute units C in said general formula above. Some especially suitable water soluble, blue light activated photocrosslinkers according to the present invention comprise NVP together with vinyl acetate units, N,N-dimethylacrylamide units alone or together with 2-hydroxyethylethacrylate units, all

combined with VBPO units. These photocrosslinkers demonstrate high conversion rate (monomer to polymer) and suitably high stability in aqueous solution. This type of photocrosslinkers can be prepared by conventional radical polymerization.

According to an alternative aspect, the units C of said general formula radical R^4 is -O-C(O)-NH-R^8-C(O)P(O) R^9R^{10}, wherein R^8, R^9 and R^{10} are as above. The radical R^4 has in this context preferably been introduced by reacting isocyanate substituted photoactive compounds having the formula O=C=N-R^8-C(O)P(O)R^9R^{10} with hydroxyl groups on a macromolecular backbone $(A)_n(B)_m(C)_p$, wherein units C have been selected as units A and B, as above. Typically, such a backbone comprises vinyl alcohol units derived from a monomer or copolymer of vinyl acetate, which has undergone a conventional hydrolysis step. An example of such a macromolecular backbone is a copolymer of NVP and vinyl acetate or poly(vinyl acetate).

The invention further relates to a method of forming a macromolecular crosslinked network from an aqueous composition comprising a photocrosslinker according to above, by irradiating with light exceeding a wavelength of about 305 nm for a time sufficient to form a solid article. As earlier mentioned such a composition further may comprises one or several copolymerizable vinylic, acrylic or methacrylic monomer(s), or a hydrophilic polymer provided with functional vinylic, acrylic or methacrylic groups, or combinations such monomers and polymers.

The present invention is especially useful for the production of ophthalmic lenses, particularly, where biocompatibility conferred by hydrophilic compositions is advantageous. A particularly suitable application of the inventive photocrosslinkers is to use them in the preparation of intraocular lenses produced directly in the capsular bag of the eye after surgically having removed a defect natural lens. The photocrosslinker will then be a part of an ophthalmically acceptable composition having a suitable viscosity and fluid characteristics for being injected into the eye with conventional equipment.

The photocrosslinkers according to the present invention provide for a combination of photoinitiating and crosslinking processes. It is an important feature of the present invention to effect this combination of function by attaching photoactive groups to a polymeric or macromolecular structure. The photoactive groups, when exposed to light of

the appropriate wavelength, will undergo photoinduced scission and generating radicals, which are retained on the polymeric or macromolecular structure. These retained radicals then initiate, terminate, or, in some other way participate in the gel forming process that is the objective of the radiation cure of the photomaterial. The use of the inventive photocrosslinkers confers distinct advantages, both chemical and environmental, as compared with the combination of a separate photoinitiator and crosslinker. In a chemical context the use of a photocrosslinker gives opportunities to produce networks that are more homogeneous than those produced by photocuring conventional photocurable systems. The latter systems, involving as they do, combinations of monomers, have structures dependent on the reactivity ratios of the monomers and crosslinkers. Often, for example, in a coating being manufactured at high rates of production, a crosslinker is selected because of its high reactivity. Disparities in the reactivates of the components of a formulation gives rise to compositional drift, the change of the average unit composition during the course of a polymerization, and this in relation to a reactive crosslinker implies that sections of a network forming later, in the curing process, have a lower crosslink density than sections formed earlier. Improving the homogeneity of crosslinked networks is a subject receiving greater attention as the technical demands imposed on industrial products increases. Homogenous networks have, for example, higher fracture toughness and better optical properties heterogeneous networks. The shrinkage occurring during their formation is more uniform allowing for more precision in castings. The benefits of using a photocrosslinker as a network former, as compared with a combination of photoinitiator and crosslinker, arise because the radical species they produce act as crosslinkers *via* the polymer chain to which they are attached. Further such radicals are generated throughout the setting phase, their concentration being controlled by the photoinitiating species' quantum efficiency and the intensity of the light, which may be modulated during the setting, in addition to its concentration. This distinction results in the formation of networks having a more controlled and homogeneous structure.

Retaining photoinitiator residues in the network of a medical product, such as a contact lens or a dental filling has desirable physiological implications. Further

photocrosslinkers because of their polymeric, or macromolecular, nature are more acceptable, environmentally, than many conventional crosslinkers which are known to cause skin and lung irritation.

Within the context of the present invention, it is possible to substitute a photocrosslinker, either completely, or partially, for a combination of a conventional photoinitiator and a conventional crosslinker. Alternatively, the inventive photocrosslinkers can be used in combination with a conventional photoinitiator or a conventional crosslinker as will be understood by practitioners skilled in formulating systems for crosslinking.

Persons skilled in this art will also appreciate that the inventive photocrosslinkers as described herein for photoactive systems responsive to visible light may be applied equally to systems responsive to UV light, so the present invention is of very general applicability.

Detailed and exemplifying description of the invention

Example 1

PHOTOCROSSLINKER POLYMER PREPARATIONS

Table 1

photocrosslinkers	**VBPO** (mole%) 1	**Comonomer 1** (mole%)	**Comonomer 2** (mole%)
P31-1	3.5	HEMA(5)	NVP(91.5)
P32-1	3.5	VAc(10)	NVP(86.5)
P40-3	4	DMA(96)	none

P40-4	4	PEMA(96)	none
P41-1	6	DMA(94)	none

The following Examples describe the preparation of P32-1(3), P40-3 & P41-1 (comparison), and P40-4 respectively. In addition examples demonstrating photocrosslinkers of DMA and 4-vinyl-2,6-dimethylcbenzoylphosphine oxide are added (Examples 1E and 1F).

Example 1A

Photocrosslinker Copolymer employing N-Vinylpyrrolidone and Vinyl acetate

This preparation, on an 8g monomer scale, used monomers in the molar ratio: 86.5 parts N-vinylpyrrolidone (VP): 10 parts vinyl acetate (Vac): 3.5 parts vinylbenzoyldiphenylphosphine oxide (VBPO).

Methoxydiphenylphosphine, 0.520g, was weighed to a dried 100ml twin-neck flask, with one neck septum sealed, and coated in aluminium foil to exclude light. Toluene, 3 ml, and a magnetic stir bar were added and the flask flushed with dry nitrogen. The stopcock was briefly removed and 4-vinylbenzoyl chloride, 0.409g, added, the flask being again flushed with dry nitrogen, then placed in a bath at 65°C, with magnetic stirring.

After 15 minutes, the other monomers: VP, 6.620g, and Vac, 0.595g, were diluted with a previously prepared solution of azobisisobutyronitrile (AIBN), 0.080g in 8ml toluene, and the mixture injected to the flask and rinsed in with a further 4ml toluene. The polymerization mixture was heated at 65°C with magnetic stirring for 8 hours, yielding a clear pale yellow solution, which was precipitated, in subdued light, to diethyl ether. The supernatant was discarded and the pale sludge-like precipitate taken up in 30ml methanol and reprecipitated to ether as a curdy precipitate. The supernatant was decanted, and the polymer product dried to constant weight under vacuum at 35°C . Yield was 5.751g (72%) of friable pale yellow polymer. Elemental analysis gave 0.65%

P, corresponding to 6.9%ww VBPO units (0.209mmol/g), and 10.70% N, corresponding to 84.5%ww VP units, and thus a mean unit mass of 115 Daltons. SEC gave Mn 32,000 , Mw 103,000. This implies a number average chain length of ca.280 units, with ca.7 photoactive units per chain.

Example 1B

Photocrosslinker Copolymer employing N-Dimethylacrylamide (I)

In this example, 4-vinylbenzoyldiphenylphosphine oxide (VBPO), 4 mol%, was copolymerized with N,N-dimethylacrylamide (DMA), 96 mol%, on a 6g scale.

Methoxydiphenylphosphine, 0.481g, was weighed to a dried 24x150mm Quickfit tube, and 2.5ml dry toluene added. The tube was then wrapped in aluminium foil to exclude light. 4-Vinylbenzoyl chloride, 0.368g, and a magnetic stir bar were added, and the tube septum sealed, N_2 flushed, and placed in a bath at 65°C with stirring. After 15 minutes a solution of DMA, 5.26g, and AIBN, 0.060g, in toluene, 5ml, was injected by syringe and rinsed in with a further 3.6ml toluene. The mixture was stirred 6h at 65°C, yielding a viscous orange-yellow solution, which was diluted with methanol and precipitated in diethyl ether. The product was reprecipitated from methanol to ether, and vacuum dessicated at room temperature. Yield, 2.56g (43%) of friable pale yellow polymer, analysis 0.82% P corresponding to 8.8%ww VBPO units (0.265mmol/g). GPC using poly(ethylene glycol) standards gave Mn 25,000; Mw 100,000 .

Example 1C

Photocrosslinker Copolymer employing N-Dimethylacrylamide (II)

Example 2B was repeated on a 12 g scale, but with monomer ratio 6 mol% VBPO (2.12 g), 94 mol% DMA (9.89 g), with 0.120 g AIBN, 22.3 ml toluene, and polymerization time extended to 8h at 65°C. The yield was 7.17g (60%) of yellow polymer, analysis

1.49% P corresponding to 16.0 %ww VBPO (0.481mmol/g).GPC gave Mn 12 000 and Mw 88000.

Example 1D

Photocrosslinker Copolymer employing 2-Phenylethyl methacrylate

In this example, 4-vinylbenzoyldiphenylphosphine oxide (VBPO), 4 mol%, was copolymerized with 2-phenylethyl methacrylate (PEMA), 96 mol%, on a 6g scale.

Methoxydiphenylphosphine, 0.271g, was weighed to a dried 24x150mm Quickfit tube, and 2.5ml dry toluene added. The tube was then wrapped in aluminium foil to exclude light. 4-Vinylbenzoyl chloride, 0.204g, and a magnetic stir bar were added, and the tube septum sealed, N_2 flushed, and placed in a bath at 65°C with stirring. After 15 minutes a solution of PEMA, 5.60g, and AIBN, 0.060g, in toluene, 5ml, was injected by syringe and rinsed in with a further 3.6ml toluene. The mixture was stirred 6h at 65°C, yielding a fairly viscous pale yellow solution, which was diluted with chloroform and precipitated to methanol. The product was reprecipitated from chloroform (with THF added to clarify the solution), and vacuum dessicated at room temperature. Yield, 4.67g (78%) of friable pale yellow polymer, analysis 0.48% P corresponding to 5.2%ww VBPO units (0.155mmol/g). GPC in THF using polystyrene standards gave Mn 49,300; Mw 108,500 .

Example 1E

In this example, 4-vinyl-2,6-dimethylbenzoyldiphenylphosphine oxide (VDMBPO), 4 mol%, was copolymerized with N,N-dimethylacrylamide (DMA), 96 mol%, on a 12g scale.

Methoxydiphenylphosphine, 0.979g, was weighed to a dried flask and 5ml dry toluene added. The flask was wrapped in aluminium foil to exclude light. 4-Viny-2,6-dimethyllbenzoyl chloride, 0.885g, and a magnetic stir bar were added, and the flask

septum sealed, N_2 flushed, and placed in a bath at 65°C with stirring. After 15 minutes a solution of DMA, 10.426g, and AIBN, 0.121g, in toluene, 9.3ml, was injected by syringe and rinsed in with a further 8ml toluene. The mixture was stirred 8h at 65°C, yielding a viscous pale yellow solution, which was diluted with 20ml ethanol and precipitated in diethyl ether. The product was reprecipitated from ethanol to hexane, and vacuum dessicated at room temperature. Yield, 8.53g (71%) of friable pale yellow polymer, analysis 0.58% P corresponding to 6.75%ww (1.95mol%) VDMBPO units (0.187meq/g).

The polymer was water soluble and showed excellent hydrolytic stability; tested over the course of a year the product showed no measurable decrease in photoactivity. GPC gave Mn 6,000; Mw 26,000 .

Example 1F

Example 1E was repeated employing VDMBPO 5 mol and DMA 95 mol%. Yield was 43% of pale yellow polymer, analysis 0.86% P corresponding to 10.0%ww (2.97mol%) VDMBPO units (0.278meq/g). GPC gave Mn 7,000; Mw 32,500.

Example 1G

Example 1F was repeated employing VDMBPO 5 mol% and DMA 95 mol%. Yield was 55% of pale yellow polymer, analysis 0.73% P corresponding to 8.5%ww (2.49mol%) VDMBPO units (0.236meq/g). GPC gave Mn 5,600; Mw 24,000.

EXAMPLE 1H

1,3,5-trimethylbenzoyl-styrylphenylphosphine oxide (TMBSPO), 4 mol%, was copolymerized with N,N-dimethylacrylamide (DMA), 96 mol%, on a 12g scale.

First methoxystyrylphenylphosphine, 0.800g, was weighed to a dried flask and 5ml dry toluene added. The flask was wrapped in aluminium foil to exclude light. 1,3,5-trimethyllbenzoyl chloride, 1.061g, and a magnetic stir bar were added, and the flask septum sealed, N_2 flushed, and placed in a bath at 65°C with stirring. After 15 minutes

subsequently a solution of DMA, 10.241g in 15 mL of toluene, and AIBN, 0.120g in 5.0 mL of toluene, were injected by syringe. The mixture was stirred 8h at 65°C, yielding a viscous pale yellow solution, which was diluted with 20ml ethanol and precipitated in diethyl ether. The product was reprecipitated from ethanol to diethylether, and vacuum dessicated at room temperature. Yield was 55% of pale yellow polymer, analysis 0.87% P corresponding to 10.4%ww (2.40mol%) TMBSPO units (0.227meq/g). GPC gave Mn 9,000; Mw 35,000.

The experiment was repeated employing TMBSPO 2.5 mol% and DMA 97.5 mol%. Yield was 79% of pale yellow polymer, analysis 0.43% P corresponding to 5.1%ww (1.19mol%) TMBSPO units (0.112meq/g). GPC gave Mn 15,000; Mw 94,000.

Finally, the experiment was repeated employing TMBSPO 4 mol% and PEMA 96 mol%. Yield was 68% of friable pale yellow polymer, analysis 0.56% P corresponding to 5.4%ww TMBSPO units (0.149mmol/g). GPC gave Mn 19,000 and Mw 165,000.

Example 1I

This example illiustartes the preparation of photocrosslinkers having photoactive agent linked to the ethylene backbone by a group comprisng a urethane bond.

1 Hydrolysis of poly(N-vinylpyrrolidone-vinylacetate) 60:40]

For this preperation, poly(NVP-co-VAc) 60:40 (Polysciences Inc., Mw 100,000; 40 g , 0.16 mole acetategroups) was dissolved under nitrogen in methanol (200 ml) and heated to 40°C. To this solution NaOH (6.4 g, 0.16 mol) in distilled water (8.0 ml) was added. After one night of reaction the solution was cooled to RT and neutralised with hydrochloric acid (33% aquous water solution). The polymer solution was separated from precipitated salts and dialysed (Spectrapor 6 dialysis tubes, MWCO: 1000) against frequently refreshed distilled water for two days. After dialysis the polymer solution was concentrated with a rotary evaporator and diluted with methanol (150 ml). It was precipitated to 1 liter of diethylether. The precipitated poly(NVP-co-VA) 60:40 was

powdered and dried over SICAPENT (Merck) for one week at 40°C in a vacuum oven connected to an oil pump, until constant weight was reached.

2 Synthesis of 4-isocyanatobenzoyldiphenylphosphineoxide (IBPO)

This reaction was performed in subdued light under an inert nitrogen atmosphere. To an oven dried threeneck flask methoxydiphenylphosphineoxide (0.177g , $6.65x10^{-4}$ moles) was added, followed by dry tetrahydrofurane (THF, 10 ml). The flask was wrapped in aluminium foil, to shield the reaction from outer light. The temperature was raised to 65°C. Now 4-isocyanatobenzoylchloride (Aldrich; 0.116g, $6.98x10^{-4}$ moles, 1.05 eq.) was added in dry THF (10 ml). After a reaction time of one hour the solvent was evaporated, and the product was retrieved as a pale yellow solid. Yield: 0.192g , 83%. Analysis with ^{1}H-NMR in DMSO-*d6* showed a typical pattern for the photoinitiator (PI) in the aromatic region of the spectrum, while the absorptions for the starting products had virtually vanished. This product was directly used without further purification in the next step.

3 Synthesis of 4-isocyanato-3,5-dimethylbenzoyldiphenylphosphineoxide

The reaction in example 2 was repeated with 4-isocyanato-3,5-dimethylbenzoylchloride instead of 4-isocyanatobenzoylchloride.

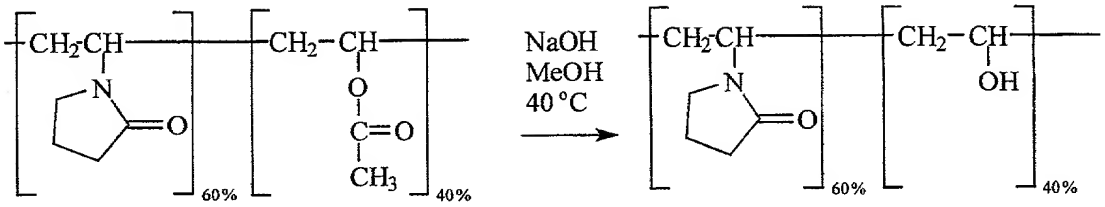
4 Synthesis of photocrosslinker by modification of poly(NVP-co-VA) 60:40 with IBPO

This reaction was performed in subdued light under an inert nitrogen atmosphere. To an oven dried threeneck flask 2 g of poly(NVP-co-VA) 60:40 was added and dissolved in 50 ml of dimethylacetamide (DMAA) at 40°C. Now 10 ml of DMAA was added to the reaction flask with the previous prepared IBPO, and the resulting light yellow solution was added to the poly(NVP-co-VA) 60:40 solution. After a reaction time of one night it was precipitated to diethylether (350 ml). The light yellow sticky polymer

was redissolved again in 30 ml of methanol and reprecipitated to 300 ml of diethylether. The polymer was collected over a Buchner funnel and dried for one night in a vacuum oven at 35°C. A light yellow rubbery polymer was retrieved. Yield: 1.824g (91%). With ^{1}H-NMR in DMSO-*d6* it was found that the IBDPPO had reacted with the copolymer, and its content was estimated as 2.7 mole%. It produced a crosslinked waterswellable elastic material after blue light irradiation in an experiment where it was dissolved in water together with a polymeric crosslinker.

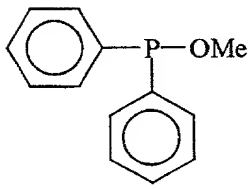
Synthesis of photocrosslinker by modification of poly(NVP-co-VA) 60:40 with IDMBPO

The reaction in example 4 was repeated with IDMBPO instead of IBPO. Similar yields and results could be achieved.

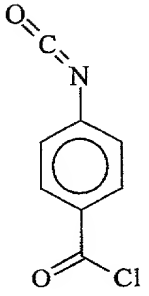


poly(NVP-co-VAc) 60/40

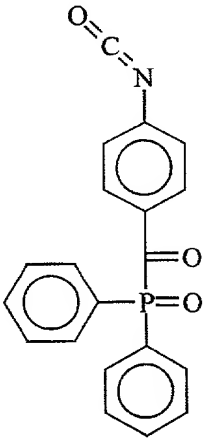
poly(NVP-co-VA) 60/40



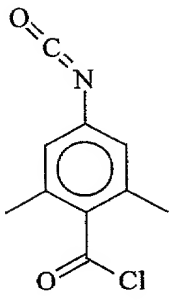
methoxydiphenyl-phosphineoxide



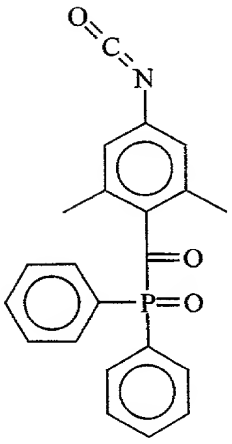
4-isocyanato-benzoylchloride



IBPO



4-isocyanato-3,5-dimethyl benzoylchloride



IDMBPO

Example 2

The following examples refer to photopolymerization including the inventive photocrosslinkers compared with photopolymerization with commercially available photoinitiators.

Example 2A

The state of the art photoinitiator Irgacure 1800 (ex Ciba-Geigy, 10.0 mg) was dissolved, in subdued light, in 2-hydroxyethylmethacrylate (HEMA, ophthalmic grade ex Polysciences, 970 mg) and 1,6-dihydroxyhexane diacrylate (HDDA, ex, 20.0 mg), and a 10.0 mg sample pipetted into an open DSC aluminum sample pan. The sample pan, covered with a cover-slip of thin glass, was placed in the sample position of the head of a TA Instruments Differential Photocalorimeter (DPC). The temperature of the head was allowed to stabilize under N_2 at 37°C (or in some cases 23°, and the sample irradiated with blue light at an intensity of 8-9 $mWcm^{-2}$.

The area of the polymerization exotherm was determined by conventional computation and the Jg^{-1} of monomer calculated. From the Jg^{-1} the percentage conversion of monomer to polymer was calculated using a literature value for the latent heat of polymerization of the monomer, ΔH_p. The findings are collected in Table 2.

Using the same composition as was used for the DPC tests discs (2mm thick x 16mm diameter) of polyHEMA were cast in PTFE casting cells. About 500mg of the mixture of monomers and photoinitiator were introduced into the cell which was closed with a glass slide and irradiated with blue light, either from a blue light dental gun, or from a

proprietary light generator (Efos Novacure), for 3min.

Example 2B

The method described in Example 2A was repeated using with the state of the art photoinitiator Lucirin TPO (ex BASF, 10.0mg) instead of Irgacure 1800.

Example 2C

The method described in Example 2A was repeated using HEMA (900.0mg), no HDDA, and, instead of Irgacure 1800, a photocrosslinker according to the present invention (P31-1, see Table1. for composition, 100.0mg)

Example 2D

The method described in *Example 2*C was repeated using a photocrosslinker according to the present invention (P32-1, see Table 1. for composition, 100.0mg).

Example 2E

The method described in *Example 2*C was repeated using a photocrosslinker according to the present invention (P40-3, see Table 1. for composition, 100.0mg).

Example 2F

The method described in *Example 2C* was repeated using a photocrosslinker according to the present invention (P41-1, see Table 1. for composition, 100.0mg).

Example 2G

The method described in *Example 2A* was repeated using a photocrosslinker according to the present invention (P32-1, 100.0mg) instead of Irgacure 1800, HEMA (600.0mg), water(300mg) and no HDDA.

Example 2H

As *Example 2G*, using P40-3 (50.0mg) to replace P32-1, and HEMA (500.0mg), water (450.0mg).

Example 2I

As *Example 2H* using P41-1(50.0mg) to replace P40-3.

Example 2J

The method described in *Example 2A* was repeated using 2-phenylethylacrylate (PEA, 990.0mg, ex Polymer & Dajac Laboratories) instead of HEMA and no HDDA.

Example 2K

The method described in *Example 2A* was repeated using instead of Irgacure 1800 a photocrosslinker (P40-4, see Table 1. for composition, 100.0mg) and PEA (900mg) but no HDDA or HEMA.

The % conversions of monomer to polymer in Table 2., Examples 2A and 2B, the commercial photoinitiators, and the photocrosslinkers, Examples 2C to 2E, are comparable showing that the photocrosslinkers behave as efficient photoinitiators, especially giving regard to the concentrations of photoactive species, the acylphosphine oxide (shown in Table 1) Further when these findings are compared with Examples 2G to 2I the comparison reveals that correctly designed photocrosslinkers (Examples 2H and

2I) exhibit 100% conversions in solution in water.

For the 2-phenylethylacrylate monomer the photocrosslinker P40-4, based on 2-phenylethylmethacrylate, is also very efficient as a photoinitiator (comparing Examples 2J and 2K) giving 100% conversion of monomer to polymer gel, as judged from the heat of polymerization (based on experimentally determined ΔH_p).

Table 2. A comparison of the completeness of blue light photopolymerisation of HEMA, HEMA in water, & PEA using low molecular weight photoinitiators and photocrosslinkers

Ex. No.	**Formulation**[a] (wt%)[m.eq photoactive ingredient[b]/100g]	**Heat of Polym.** (Jg^{-1})	**Polym. time** (min)	**Conversion** %
2A	HEMA(97)HDDA(2)I1800(1)[0.51]	351	3.5	80
2B	HEMA(97)HDDA(2)TPO(1)[2.9]	357	1.5	82
2C	HEMA(90)P31-1(10)[2.0]	308	6	70
2D	HEMA(90)P32-1(10)[2.3]	309	3	71
2E	HEMA(90)P40-3(10)[2.7]	307	2	70
2F	HEMA(90)P41-1(10)[4.8]	361	1.5	82
2G	HEMA(60)H_2O(30)P32-1(10)[2.3]	>275	>7	>63
2H	HEMA(50)H_2O(45)P40-3(5)[1.4]	452	7	100(approx.)
2I	HEMA(50)H_2O(45)P41-1(5)[2.4]	454	6	100(approx.)
2J	PEA(99)I1800(1)[0.51]	455	2.5	100(approx.)
2K	PEA(90)P40-4(10)[1.6]	456	3.5	100(approx.)

[a]Photocrosslinkers, and monomer HEMA, as Table 1.: commercial photoinitiators I1800, bis(2,6-dimethoxybenzoyl)-trimethylpentylphosphine oxide (25%) + 1-hydroxy-cyclohexylphenylketone (75%)(Irgacure 1800 ex Ciba-Geigy)

TPO, 1,3,5-trimethylbenzoyldiphenylphosphine oxide (Lucirin TPO ex BASF): monomer PEA, 2-phenylethylacrylate: crosslinker HDDA, hexan-1,6-diol diacrylate

[b]m.eq. of acylphosphine oxide/100g of formulation.

Example 3

Examples for Gelation Tests:

Examples 3A and 3B

Using the formulations described above in Examples 2J and 2K and the casting method described in *Example 2A* discs were prepared.

Example 3C

Irgacure 2959 (ex Ciba-Geigy, 10.0 mg) was dissolved, in subdued lighting, in 2-hydroxyethylmethacrylate (HEMA, ophthalmic grade ex Polysciences, 550.0 mg) and water (440.0 mg). Test discs (2mm thick x 16mm diameter) of polymer were cast in PTFE casting cells. About 800mg of the mixture of monomers and photoinitiator were introduced into the cell which was closed with a glass slide and irradiated with light from a proprietary light generator (Efos Novacure), for 3 min.

Example 3D

As *Example 3C* with Irgacure 2959 (30.0 mg), HEMA (540.0 mg) and water (430.0 mg).

Example 3E

As *Example 3C* with P40-3 (100.0 mg) replacing Irgacure 2959, HEMA (500.0mg), and water (400.0mg).

Example 3F

As *Example 3C* with P41-1 (70.0mg) replacing Irgacure 2959, HEMA (510.0mg), and water (420.0mg).

Example 3G

As *Example 4C* with P40-4 (50.0mg) replacing Irgacure 1800, PEA (900.0mg), and additional crosslinker, CE7-2 (2-phenylethylmethacrylate/2-hydroxy-3-acryloxypropylmethacrylate copolymer [0.9:0.1 mole ratio], 50.0mg).

Example 3H

As *Example 3G* with Irgacure 1800 (21.0mg) replacing P40-4, PEA (940.0mg), and crosslinker, CE7-2 (2-phenylethylmethacrylate/2-hydroxy-3-acryloxypropylmethacrylate copolymer [0.9:0.1 mole ratio], 60.0mg).

Example 3I

As *Example 3B* with PEA (750.0mg), and photocrosslinker, P40-4 (250.0mg).

In Table 3. are collected the tests made to check the gelation of the different formulations. Where a composition is gelled it does not dissolve in solvent, but swells to an extent related to its crosslink density. Uncrosslinked (sol) polymers dissolve.

Examples of monomers photopolymerized with conventional photoinitiators of low molecular weight, nos. 4A, 4C and 4D dissolved readily in the appropriate solvent, water for polyHEMA, and acetone for polyPEA. Example no. 4B showed an intermediate behavior and dissolved partially in acetone leaving some residual gel. Increasing the proportion of photocrosslinker to 25% (3.9m.eq. of acylphosphine oxide, Example 4I or, adding separate crosslinker, CE7-2 (Example 4G, see below) produced acetone insoluble gel.

CE7-2, a polyPEMA which is unsaturated and PEA miscible, being a copolymer of 2-phenylethylmethacrylate/2-hydroxy-3-acryloxypropylmethacrylate [0.9:0.1 mole ratio], was employed as a supplementary crosslinker to the photocrosslinker P40-4, in Examples 4G and 4H. That CE7-2 is an effective cross-linker for photopolymerized PEA is demonstrated in example no. 4H, where in combination with Irgacure 1800 it also yields a gelled product upon irradiation. The products upon irradiation are transparent gelled elastomers of high refractive index (RI>1.54), similar in properties to PEA/PEMA copolymers.

Examples 3E and 3F which used photocrosslinkers to replace conventional photoinitiators for HEMA/water compositions were gelled and did not dissolve in water, unlike examples 4D and 4E.

Table 3. Gelation tests on photopolymerized materials, shewing effect of photocrosslinkers

Ex. No.	Formulation (wt%)[1]	Effect of Solvent	Comments
3A	PEA(99)I1800(1)	Dissolves in Acetone	Not Crosslinked
3B	PEA(90)P40-4(10)	Dissolves & Swells in Acetone	Lightly Crosslinked
3C	HEMA(55)H_2O(44)I2959[2](1)	Dissolves in Water	Not Crosslinked

3D	HEMA(54)H_2O(43)I2959(3)	Dissolves in Water	Not Crosslinked
3E	HEMA(50)H_2O(40)P40-3(10)	Swells in Water	Crosslinked Gel
3F	HEMA(51)H_2O(42)P41-1(7)	Swells in Water	Crosslinked Gel
3G	PEA(90)CE7-2(5)P40-4(5)	Swells in Acetone	Crosslinked Gel
3H	PEA(94)CE7-2(6)I1800(2.1)	Swells in Acetone	Crosslinked Gel
3I	PEA(75)P40-4(25)	Swells in Acetone	Crosslinked Gel

[1] See Tables 1. & 2., and text for an explanation of materials codes

[2]I2959, 2-hydroxy-4'-hydroxyethoxy-2-propiophenone (UV curing)

The crosslinked structure of the water swollen hydrogels (4E and 4F) was confirmed by stress relaxation tests.

Example 4

The method described in Example 2A was repeated using the following formulations:

Formulations (wt %)

4A. water (80)/photocrosslinker according Example 1F(20)

4B. water (80)/photocrosslinker according Example 1H(20)

4C. HEMA(45)/water(35)/photocrosslinker according to Example 1C(20)

4D. HEMA(45)/water(35)/photocrosslinker according to Example 1F(20)

4E. HEMA(45)/water(35)/photocrosslinker according Example 1H(20)

4F. HEMA(45)/H20(35)

The coherent and clear gels resulted from the irradiation of the formulations with blue light, and their relative crosslinked nature was characterized in two ways. The first method was to measure the stress relaxation of the networks, using a Rheometrics RDA-11, and the second method used was to measure the smiling of the gels in water.

Stress Relaxation Tests-Method

The RDA-11 was set up with the 16mm gelled sample damped between parallel plates of 25 mm, heated to 35°C, and a strain of 30% applied. During the test the instrument measures the instantaneous stress necessary to maintain 35%, and plots the instantaneous shear modulus (Gi) against log t. In Table 3, the percentage reductions in the modulus Gi for the formulations 4A to 4F between i = 10 and 100 s are compared as (G(10) – G(100)/G(10))x100 both before and after swelling in water. The results confirm that the photocrosslinked gel possess coherent network structures.

Table 3. Average Stress Relaxations of Photocrosslinked Formulations 4A to 4F, measured at 35°C

Average stress relaxation	4A	4B	4C	4D	4E	4F
Before swelling-disc1	No result		4.9	3.4	No result	Not measurable
Before swelling-disc2	9.3		15.5	10.9	29.4	
After swelling-disc1			21.4	17.4		
After swelling-disc2	19.1		19.0	13.0	12.4	Not measurable

Swelling Test Method

Samples discs from formulations 4A through 4F were weighed, immersed in water for 24 hours at 20°C, dried, and reweighed. Table 4 compares the water absorbed by each formulation on a percentage basis.

Table 4.

Percentage water absorbed at 25°C by photocrosslinked gels

Water absorbed (wt %)	4A	4B	4C	4D	4E	4F
Disc1			222	191		Not measurable
Disc2	130	219	230	172	255	Not measurable

It was observed that upon irradiation with blue light, the formulation prepared without a crosslinker (4F) did not gel and that no discs suitable for any measurements were formed. Satisfactory discs were prepared from other formulations and stress relaxation results and the water absorption results were in agreement with the sequence: most highly crosslinked 4A>4C<4E least highly crosslinked.

Claims

1. Macromolecular hydrophilic photocrosslinkers having a general formula

$(A)_n(B)_m(C)_p$

capable of producing, upon exposure to light, crosslinked networks, wherein

(i) A, B and C are units of substituted ethylene groups in the macromolecular structure;

(ii) A, B and C are randomly distributed and the unit C carries a photoactive group;

(iii) n = 0-98 mole %, m = 0-98 mole %, n+m = 50-98 mole % and p = 0.5-50 mole %;

and when said photoactive groups are exposed to light of determined wavelengths above 305 nm, radicals are generated and retained on the macromolecular photocrosslinkers and reacting so as to accomplish a crosslinked network structure.

2. Photocrosslinkers according to claim 1 characterized in that said photoactive group comprises a phosphine oxide.

3. Photocrosslinkers according to claim 2 characterized in that the photoactive group is an acyl- or aroyl phosphine oxide.

4. Photocrosslinkers according to claim 3 characterized in that the photoactive group is linked to the ethylene groups of units C by a linking group comprising a phenylene group, said phenylene group being optionally substituted.

5. Photocrosslinkers according to claim 3 characterized in that the photoactive group is linked to the ethylene groups of units C by a linking group comprising a group having the structure

–O-C(O)-NH-.

6. Photocrosslinkers according to claim 5, wherein the linking group has the structure of -O-C(O)-NH-Ph-, wherein Ph denotes an optionally substituted phenylene group.

7. Photocrosslinkers according to claim 1, wherein the ethylene units A, B, C of the macromolecular structure comprises substituents in accordance with:

A= $-CH_2-C(R^1R^2)-$, B= $-CH_2-C(R^1R^3)-$, C= $-CH_2-C(R^1R^4)-$, wherein

R^1 is hydrogen or methyl;

R^2 is $-CON(Me)_2$, $-CO_2CH_2CH_2OH$, $-OCOCH_3$, $-OCOCH_2CH_2Ph$, -OH or a lactam group;

R^3 is $-CON(Me)_2$, $-CO_2CH_2CH_2OH$, $-OCOCH_3$, $-OCOCH_2CH_2Ph$, -OH or a lactam group when B is $-CH_2-C(R^1R^3)-$ with the proviso that R^2 and R^3 are not the same unless R^2 and R^3 is -OH ; and

R^4 is $-R^5C(O)P(O)\ R^6R^7$ or $-R^5P(O)R^6OC(O)R^7$, wherein R^5, R^6 and R^7 are selected among same or different aryl groups comprising phenyl, methylphenyl, dimethylphenyl, trimethylphenyl, methoxyphenyl, dimethoxyphenyl, trimethoxyphenyl, methylolphenyl, dimethylolphenyl, trimethylolphenyl or styryl radicals, or

R^4 is $-R^8C(O)P(O)\ R^9R^{10}$, wherein R^9 and R^{10} are the same as R^5, R^6 and R^7 above, but R^8 is a group –O-C(O)-NH- R^{11}, wherein R^{11} is the same as R^9 and R^{10}.

8. Photocrosslinkers according to claim 7, wherein R^2 and R^3 are selected so as to form a water-soluble molecule.

9. Photocrosslinkers according to claim 7, wherein said lactam units together with units A or B constitute N-vinylpyrrolidone units.

10. Photocrosslinkers according to claim 7, wherein at least one of R^2 and R^3 is hydroxyl.

11. Photocrosslinkers according to claim 7, wherein A is N-vinylpyrrolidone, B is vinyl alcohol.

12. Photocrosslinkers according to claim 7, wherein R^4 is – O-C(O)-NH-R^8-C(O)P(O) R^9R^{10}.

13. Photocrosslinkers according to claim 1 or 7 provided with functional groups for crosslinking.

14. Photocrosslinkers according to claim 13 provided with functional groups selected among vinylic, acrylic and methacrylic groups.

15. A method of preparing a photocrosslinker from a hydrophilic macromolecule $(A)_n(B)_m(C)_p$

(i) A, B and C are units of substituted ethylene groups in the macromolecular structure;

(ii) A, B and C are randomly distributed and at least the unit C carries a hydroxyl group;

(iii) n = 0-98 mole %, m = 0-98 mole %, n+m = 50-98 mole % and p = 0.5-50 mole %;

by reacting said macromolecule with an isocyanate substituted photoactive agent having the structure -C(O)=N-R^8-C(O)P(O) R^9R^{10}, wherein R^8, R^9 and R^{10} are selected among same or different aryl groups comprising phenyl, methylphenyl, dimethylphenyl, trimethylphenyl, methoxyphenyl, dimethoxyphenyl, trimethoxyphenyl, methylolphenyl, dimethylolphenyl, trimethylolphenyl or styryl radicals.

16. A method of forming a macromolecular crosslinked network from an aqueous composition comprising a photocrosslinker according to any of claims 1 to 14 by

irradiating with light exceeding a wavelength of about 305 nm for a time sufficient to form a solid article.

17. A method according to claim 16, wherein said composition further comprises at least one copolymerizable vinylic, acrylic or methacrylic monomer.

18. A method according to claim 16, wherein said composition further comprises a hydrophilic polymer provided with functional vinylic, acrylic or methacrylic groups.

19. A method according to claim 18, wherein said hydrophilic polymer forms discreet crosslinkable units in form of water-soluble particles.

20. A method according to any of claims 16 to 19, wherein an ophthalmic lens is produced from said composition.

21. A method according to any of claim 20, comprising the steps of injecting said composition into the capsular bag of the eye and crosslinking it into a final lens product by irradiation of a wavelength exceeding 305 nm.

22. An ophthalmically acceptable composition comprising the photocrosslinkers according to any of claims 1 to 15 having a refractive index of at least 1.39 and a suitable viscosity to be injected through a standard cannula of 15 Gauge, or finer.

23. The use of photocrosslinkers according to any of claims 1 to15 in an ophthalmically acceptable composition for injection into the capsular bag of the eye.

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DECLARATION
and
POWER OF ATTORNEY

U.S. NATIONAL PHASE OF INTERNATIONAL APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **Hydrophilic Macromolecular Compounds**, the specification of which was filed as International Application No. PCT/EP00/02537 on March 16, 2000,

[ ] and was amended under Article 19 on _____. (if applicable)

[ ] and was amended under Article 34 on _____. (if applicable)

[X] and was assigned U.S. Application Serial No. 09/936,653, and was amended on September 14, 2001.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits and/or U.S. Provisional application priority benefits under Title 35, United States Code, §119 of any foreign application(s) or U.S. Provisional applications for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign and U.S. Provisional Application(s)				
			Priority Claimed	
Number	Country	Day/Month/Year Filed	Yes	No
9900935-9	Sweden	March 16, 1999	X	

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulation, §1.56(a) which

occurred between the filing date of the prior application and the PCT international filing date of this application:

_____

(Application Serial No.) (Filing Date) (Status) (patented, pending, abandoned)

I hereby appoint Holly D. Kozlowski, Registration No. 30,468; Ronald J. Snyder, Registration No. 31,062; James D. Liles, Registration No. 28,320; Lynda E. Roesch, Registration No. 29,696; Martin J. Miller, Registration No. 35,953; John V. Harmeyer, Registration No. 41,815; Scott N. Barker, Registration No. 42,292; Stephen S. Wentsler, Registration No. 46,403, and Ryan O. White, Registration No. 45,541; Charles H. Brown III, Registration No. 48,866; Jeffrey R. Schaefer, Registration No. 48,514; Todd W. Minor, Registration No. 48,965; John F. Colligan, Registration No. 48,240; Rebecca A. Brown, Registration No. 47,452; and Clayton R. Kuhnell, Registration No. 48,691, my attorneys, c/o Dinsmore & Shohl, 1900 Chemed Center, 255 East Fifth Street, Cincinnati, Ohio 45202 (513) 977-8200, my attorneys, with full power in each of them, of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

The undersigned hereby authorizes the above-named U.S. attorneys to accept and follow instructions from **Pharmacia Groningen BV** as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the undersigned and the aforenamed U.S. attorneys. In the event of a change in the firm or persons from whom instructions may be taken, the aforenamed U.S. attorneys will be so notified in writing by the undersigned.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

****

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Inventor's signature _____ 07/12/07
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